ANALYSIS OF DATA FROM THE ACOUSTIC SURFACE REVERBERATION EXPERIMENT - ASREX

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LONG TERM GOALS

To contribute to a better understanding of the environmental parameters that are most appropriate for use in predicting acoustic surface scattering strengths (SSS) in both shallow and deep-water environments.

SCIENTIFIC OBJECTIVES

To quantify the contribution of environmental parameters to acoustic surface-zone scattering using multivariate analysis techniques and the acoustic and environmental data sets collected during the Acoustic Surface Reverberation Experiment (ASREX).

APPROACH

Time series of acoustic SSS and environmental parameters, including: wind speed and direction, significant wave height, air and sea temperatures, currents, near surface sound speed, and high frequency scattering cross-sections, were put on a common time base and analyzed using both traditional correlation and multivariate Fourier analysis techniques. Time series were also filtered to isolate extreme conditions of parameters to determine what effect, if any, they have in modulating the overall dominant wind speed effect.

WORK COMPLETED

Software, including a multivariate analysis code based on the work of Bendat and Piersol[1] was developed and refined. Time series of acoustic SSS at 100, 200, 400, and 800 Hz and environmental parameters from the ASREX experiment were analyzed using this software

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and others developed by Drs. Frank Henyey and Jim Grochocinski of the University of Washington, Applied Physics Lab (UW/APL). ASREX data was provided to Dr. Eric Thorsos, also of UW/APL and Drs. Jeff Hanson and Michael Mandelburg of Johns Hopkins University, Applied Physics Lab (JH/APL) for use in their research. An ASREX web site was established at http:www.rsmas.miami.edu/groups/asrex.

RESULTS

Wind speed was found to be the dominant environmental parameter at all frequencies above I 00 Hz, but significant wave height was found to contribute to an increasing portion of the SSS variance at the lower frequencies (see Figure 1). Acoustic SS S at I 00 Hz was found to have little dependence on the wind speed and had levels consistent with rough surface scattering except at the highest wind speeds (i.e. > 1 8 M/s). Overall maximum coherence values for the wind speed was O(.9) and for the significant wave height was O(.8) for the 200-800 Hz measurements. Wind stress and ambient noise were found to have coherence comparable to the wind and wave height respectively.

Quantities measured and derived from the instruments used to quantify the bubble field during ASREX had strong correlation with the SSS values as well-though not as high as the wind speed or wave parameters. Of these the logarithm of the depth averaged air volume derived from the sound speed measurements made by Dr. Ken Melville's group had the highest correlation, O(.7)) and the e-folding depth derived from Dr. David Farmer's instruments was only slightly less correlated, O(.6). The latter data was somewhat undersampled (sample rate = 2 samples/day) which might explain the lower coherence values.

Air-sea temperature difference (AT), which is indicative of the stability of the air column close to the air/sea interface, was found to be a strong modulator of SSS under certain conditions. When results taken at the same wind speeds were compared for extreme values of AT, discrepancies of up to 10 dB in SSS were found. This effect is greatest for 800 Hz at 10-12 deg grazing grazing and decreases with increasing grazing angle disappearing altogether above 28-deg grazing. This is consistent with a review of other experimental data made by Dr. Ken Gilbert of Penn State University[2] and with observations of bubble clouds made by Dr. S. A. Thorpe. [3] Extreme values of rainfall (derived from ASREX ambient noise measurements by Dr. Jeff Nystuen of UW/APL) were also found to effect SSS values, but to a much less extent.

The relationship between SSS and a number of other parameters (i.e. wave age, wave dissipation rate, current, etc.) were investigated, but none was found to be a more significant indicator of the SSS than the aforementioned wind and wave parameters.

IMPACT/APPLICATIONS

The software developed will be used in future shallow water scattering experiments to analyze the environmental dependencies of acoustic parameters such as surface and bottom scattering strengths. The effect of extreme values of air-sea temperature difference on SSS is significant and should be included in the analysis of related data sets such as those from the Critical Sea Test (CST) experiments. The ASREX data set is a large and comprehensive one and should be used in a continuing effort to understand the statistics of the scattering process.

TRANSITIONS

ASREX data was provided to Dr. Eric Thorsos, also of UW/APL and Drs. Jeff Hanson and Michael Mandelburg of Johns Hopkins University, Applied Physics Lab (JH/APL) for use in their research. Dr. Thorsos is studying the statistics of the surface scattering processes[4]and Drs. Hanson and Mandelburg are analyzing CST data and investigating the relationship between wave dissipation rate and surface scattering [5] . A web page has been established at http://www.rsmas.miami.edu/groups/asrex.

RELATED PROJECTS

Proposed research for the upcoming fiscal year will utilize the ASREX instrumentation and new equipment purchased under an ONR-sponsored equipment grant to continue our investigations of acoustic propagation in shallow waters utilizing a new facility to be established at the South Florida Testing Facility of the Naval Surface Warfare Center. Signal analysis software developed in FY97 will be used to analyze data collected in future experiments.

REFERENCES

[1]J. S. Bendat and A. G. Piersol, Random data: Analysis and Measurement Procedures. Wiley-Interscience, 1971.

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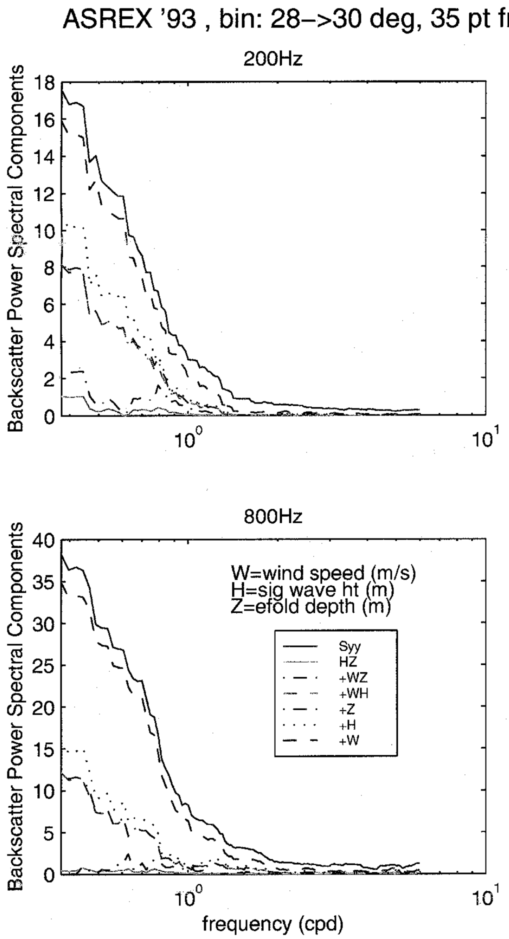

Figure 1 Multivariate analysis results for 200, 400, 800 Hz pulse data. Each line represents the addition of the portion of total scattering strength variance (as represented by the area under Syy) associated with individual variables or cross–terms. Cross–terms represent two variables acting together. Wind speed dominates at 800 Hz, but significant wave height becomes increasingly important as frequency decreases.